The Preliminary Design of the Ozone Mapping and Profiler Suite (OMPS)

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Introduction

The Ozone Mapping and Profiler Suite (OMPS) is a new US program to monitor ozone from space. It was the first sensor suite selected to fly on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) spacecraft - the successor to both the National Oceanic and Atmospheric Administration (NOAA) Polar-Orbiting Operational Environmental Satellite (POES) and Department of Defense (DOD) Defense Meteorological Satellite Program (DMSP) systems. OMPS will provide more than 20 years of total column and vertical profile ozone data. These operational data products will continue the global, daily data products similar to, but of higher fidelity than, those from the Solar Backscatter Ultraviolet radiometer (SBUV/2) and the Total Ozone Mapping Spectrometer (TOMS), and provide new, high vertical resolution limb profile data.

This entirely new program provided the Integrated Program Office (IPO, the US tri-agency - NOAA, Air Force, and National Aeronautics and Space Administration - procurement office) the opportunity to ensure optimum system performance. Their sensor system procurement process provided threshold and objective requirements for data products, allocated spacecraft accommodations and cost targets and then had a two-step competitive selection. This process encouraged industrial teams to balance hardware and algorithm performance, risk and cost issues with end users' objectives in mind – high quality, reliable, global ozone total column and profile data. NPOESS and OMPS description documents are available at the IPO electronic library at:

http://npoesslib.ipo.noaa.gov/ElectLib.htm

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OMPS Design Constraints

The OMPS design process was primarily constrained by the ozone data content and quality factors and a few significant flight system requirements. These driving system requirements include: sensor life (0.86 reliability after 8 years of storage and 7 years on-orbit); spacecraft accommodations (mass $\leq$ 45 kg, orbit average power $\leq$ 45 watts, peak data rate $\leq$ 40 kbps, and volume $\leq 0.106\ m^3$), and ozone vertical resolution $\leq$ 5 km. This vertical resolution requirement drove the design to include a limb-viewing sensor in addition to a heritage-based nadir-viewing sensor. The resulting primary spectrometer performance parameters for these sensors are listed in Table 1.

Nadir Sensor

The nadir sensor wide-field telescope feeds two separate spectrometers, one for total column observations and one for nadir profiling observations similar to SBUV/2. The total column spectrometer (300-380 nm) has a 2800 km cross-track swath divided into 35 IFOVs of nearly equal angular extent. The nadir cell is 49 km cross-track (the NPOESS C1 orbit altitude is expected to be 833 km with a 13:30 ascending node).

The nadir profile spectrometer (250-310 nm) has a 250 km cross-track swath corresponding to a single cell. Co-registration with the total column spectrometer provides the total ozone, surface and cloud cover information needed for nadir profile retrievals. The TOMS V7 algorithm has been adapted for total column retrievals. The SBUV V6 algorithm has been adopted for nadir profile retrievals.

Table 1. OMPS spectrometer performance parameters

Parameter	Nadir Total Column	Nadir Profile	Limb
Wavelength Range	300 – 380 nm	250 – 310 nm	290 – 1000 nm
Scene Radiance Range (photons/sec-cm^2-sr-nm)	9e13 (380 nm) 8e11 (308 nm)	2e13 (310 nm) 1.5e8 (252 nm)	9e13 (600 nm) 5e10 (300 nm)
Minimum SNR (Expected)	1000	35 (252 nm) 400 (310 nm)	320 (290 nm at 60 km) 1200 (600 nm at 15 km)
Integration Time	7.6 seconds	38 seconds	38 seconds
Spectral resolution	1 nm fwhm 2.4 samples / fwhm	1 nm fwhm 2.4 samples / fwhm	1.5-40 nm fwhm 1 sample / fwhm
FOV	110 x 0.3 deg	16.7 x 0.3 deg	8.5 x 2.7 deg
Cell Size	49 x 50 km at nadir	250 x 250 km	1 km vertical
Swath	2800 km	250 km	3 vertical slits along track and $\pm$ 250 km

Limb Sensor

The limb sensor uses a single prism to disperse three vertical slits directed along-track, each separated by 250 km at the limb tangent point. These slits are 150 km high in object space and are sampled at 1 km intervals. To accommodate the very high scene dynamic range, these slit images pass through a beam splitter to divide the scene brightness into three brightness ranges. As a result there are nine limb images of the dispersed slits on the CCD. The measured limb radiances in the ultraviolet, visible, and near-infrared provide data on ozone, aerosols, Rayleigh scattering, surface and clouds that are used to retrieve ozone profiles from the tropopause to 60 km. The algorithm is based on that developed for the Shuttle Ozone Limb Sounding Experiment (SOLSE) and Limb Ozone Retrieval Experiment (LORE) mission.

Calibration

Solar illuminated diffusers are used for radiometric and spectral calibrations. Due to the long orbit life requirement and the high radiometric accuracy requirements, there are two diffusers for each sensor. The working diffuser is used weekly and the reference diffuser is used twice annually to monitor the on-orbit degradation of the working diffuser. The three focal plane assemblies, including the CCDs and thermo-electric coolers, are identical, thus reducing development and production costs.

Data Products

The science community will receive operational ozone data products daily. These will be unprocessed (raw data records, e.g., level 0), geolocated and calibrated (sensor data records, e.g., level 1), and geolocated ozone total column and profile ozone data (environmental data records or EDRs, e.g., level 2) data. There are five level 2 global ozone products: three total column products (OMPS EDR, TOMS V7 and an infrared-derived product from the NPOESS Cross-track Infrared Sounder), the high vertical resolution (3 km resolution with 1 km sampling) limb profile EDR, and the SBUV V6 nadir profile data product. The algorithms are described in another Symposium talk.

Future Work

The OMPS preliminary design review was held January 1999 and the completion of the detailed design will be marked by the critical design review (CDR) scheduled for June 2003. The most significant managed risks for our detailed design efforts are: transient radiation effects on the focal planes, long term radiation effects on the CCD related to dark current and charge transfer efficiency, spectrometer internal stray light and limb ozone profile algorithm corrections for aerosols, surface scattering and cloud effects.

The NPOESS C1 satellite will be launched no sooner than September 2008, although earlier flights of opportunity for OMPS are being considered.